## SUPERFUND BENEFITS ANALYSIS

PARTIAL DRAFT – PREPARED EXCLUSIVELY FOR REVIEW BY THE EPA SCIENCE ADVISORY BOARD'S SUPERFUND BENEFITS ANALYSIS ADVISORY PANEL

DO NOT CITE OR QUOTE

January 28, 2005

Prepared for: U.S. Environmental Protection Agency Office of Superfund Remediation Technology Innovation

> Prepared by: E<sup>2</sup> Inc. Charlottesville, Virginia

> > For Further Information, Contact:
> >
> > Melissa Friedland
> >
> > <u>friedland.melissa@epa.gov</u>
> >
> > 703-603-8864

### Table of Contents

Executive Summary	<i>ES-1</i>
Chapter 1: Introduction	1-1
Chapter 2: Literature Review	2-1
Chapter 3: Superfund Responses	3-1
Chapter 4: Property-Based Valuation	4-1
Chapter 5: Effect-by-Effect Analyses	5-1
Health	5-1
Birth Defects	5-6
Acute Accidents and Injuries	5-9
Lead-Induced Health Effects	5-11
Cancer and Other Risks	5-14
Ecological	5-16
Estimating Benefits From NRDAs	5-26
Groundwater	5-33
Chapter 6: Non-Quantified Benefits	6-1
Amenities	
Materials	6-3
Empowerment	6-8
Deterrence	6-12
Emergency Preparedness	6-15
Information and Innovation	6-17
International Benefits	6-23
Chapter 7: Conclusions and Future Research	7-1
Appendix A: Data Sources	A-1
Appendix B: Case Studies	<i>B-1</i>
Appendix C: Alternative Base-Year for Discounting (2004)	<i>C-1</i>

# Figures

Figure ES.1. Figure ES.2.	Approaches Taken Under Superfund, and Resulting Benefit Categories Total Superfund Responses
Figure ES.4.	Present Value of the Benefits of NPL Site Remedial Activities, 1980-2004
r iguie Es. i.	(Billion 2000\$, Base year 1980, 2.5 miles)
Figure 1.1	Approaches Taken Under Superfund, and Resulting Benefit Categories
Figure 1.2	Benefits of the Superfund Program and Quantitative Estimates
Figure 3.1	Superfund Response Pipelines
Figure 3.1	Cumulative NPL Sites and Preliminary Assessments
Figure 3.3	Sites Reaching Various Stages in the NPL Process
Figure 3.4	Total Superfund Responses
Figure 3.5	Construction of Equivalent Area and Radii for Population Estimation
Figure 3.6	Site Areas, Distance Rings and Population Data for Two NPL Sites in
1 18410 3.0	Denver
Figure 3.7	Site Areas, 2.5-Mile Distance Rings and Population Data for NPL Sites in
8	Grand Rapids, MI
Figure 3.8	Places Near NPL Sites in the Coterminous United States (site area plus $r_{eq}$
$\mathcal{E}$	= 2.5 mile circles)
Figure 3.9	Full-Count Procedure
Figure 3.10	Cumulative Population Distribution Near All NPL sites
Figure 3.11	Distribution of Populations Near All NPL Sites (note logarithmic scale)
Figure 3.12	Cumulative Distribution of the Area of All NPL Sites
Figure 3.13	Distribution of NPL Site Areas (acres, note logarithmic scale)
Figure 3.14	Places Near NPL Sites and the Ten Largest NPL Sites in the Coterminous
	United States
Figure 3.15	Cumulative Population Distribution Near ROD Sites
Figure 3.16	Distribution of Populations Near ROD Sites (note logarithmic scale)
Figure 3.17	Cumulative Population Distribution Near MROD Sites
Figure 3.18	Distribution of Populations Near MROD Sites (note logarithmic scale)
Figure 3.19	Cumulative Population Distribution Near Property Sites
Figure 3.20	Distribution of Populations Near Property Sites (note logarithmic scale)
Figure 3.21	Cumulative Population Distribution Near HV Sites
Figure 3.22	Distribution of Populations Near HV Sites (note logarithmic scale)
Figure 3.23	Cumulative Population Distribution Near Federal Sites
Figure 3.24	Distribution of Populations Near Federal Sites (note logarithmic scale)
Figure 4.1	Areas Near NPL Sites in the Boston Area, 1982 (left) and 2004 (right)
Figure 4.2	Places Near NPL Sites in the Coterminous United States (site area plus 2.5 mile circles) and Location of Study Sites
Figure 4.3	Linear Price Effect Estimates (2000\$)

Figure 4.4	Non-Linear Price Effect Estimates (2000\$)
Figure 4.5	Mean Absolute Price Effect Estimates and 95% Confidence Intervals (2000\$)
Figure 4.6	Mean Percentage Price Effect Estimates and 95% Confidence Intervals
Figure 4.7	Sites in the NPL Pipeline
Figure 4.8	Present Value of the Benefits of NPL Site Remedial Activities, 1980-2004 (Billion 2000\$, Base year 1980, 2.5 miles)
Figure 5.1	Classification of Ecological Benefits
Figure 5.2	Cumulative Distribution of NRD Settlements
Figure 5.3	Natural Resource Damage and Potential Outcomes
Figure 5.4	Natural Resource Benefits with Natural Recovery
Figure 5.5	Natural Resource Benefits with No Recovery
Figure 5.6	Benefits of Restoration of the Lower Fox River, Using Three Different Discount Rates. (2000 \$).

# **Tables**

Table ES.1.	Categories of Benefits of Superfund
Table 1.1 Table 1.2	Superfund Approaches Brief Definitions of Benefit Categories
Table 1.3	Benefit Categories and Chapters Accomplishing Report Goals
Table 3.1	Examples of Removal Actions
Table 3.2	Total Responses and Total Superfund Responses, 1980 – 2004
Table 3.3	Definitions of NPL Site Groups
Table 3.4	Census areas with NPL sites (square miles)
Table 3.5	Characteristics of NPL Sites
Table 3.6	Populations Within 2.5 Miles of NPL Sites (thousands)
Table 3.7	Residences Within 2.5 Miles of NPL Sites (thousands) Time from Proposed NPL Listing to CC (years)
Table 3.8 Table 3.9	Area of NPL Sites (thousands of acres)
Table 3.9	NPL Sites Larger than 100,000 Acres
Table 3.11	NPL Sites with Nearby Populations Over 250,000
14010 5.11	TVI E Sites with rearby reputations ever 250,000
Table 4.1	Potential Biases in the Hedonics-Based Analysis
Table 4.2	Hedonic Price Method Studies of Homes Near Hazardous Waste Sites
Table 4.3	Events and Data Collection for HPM Study Sites
Table 4.4	Summary of Linear Price Effect Estimates Per Home (2000\$)
Table 4.5	Mean Estimates of Non-Linear Price Effect Estimates for Residences at Specified Distances (2000\$)
Table 4.6	Present Value of the Benefits of NPL Remedial Actions, 1980-2004 (Billion 2000\$, Base year 1980)
Table 4.7	Annualized Value of the Benefits of NPL Remedial Actions, 1980-2004 (Billion 2000\$, Base year 1980)
Table 5.1	Studies of Birth Defects and Hazardous Materials
Table 5.1	Studies of Acute Accidents Associated with Hazardous Substances
Table 5.3	Studies of Lead Contamination and Cleanup
Table 5.4	Studies of Cancer and Other Health Effects
Table 5.5	Natural Resource Damage Cases
Table 5.6	Studies of the Value of Ground Water
Table 5.7	Water Withdrawals in 2000 (million gallons per day)

Table 6.1	Brief Definitions of Non-Quantified Benefits
Table 6.2	Literature Relevant to Commercial and Industrial (C&I) Properties
Table 6.3	SBRP Major Research Areas

### Acronyms and Abbreviations

ACLs Alternate Concentration Limits

AM Action Memorandum

ARARs applicable or relevant and appropriate requirements

ASTSWMO Association of State and Territorial Solid Waste Management Officials

ATSDR Agency for Toxic Substances and Disease Registry

BPb blood lead BLL blood lead level

BLRA baseline risk assessment
C&I commercial and industrial
CAG Community Advisory Group
CCD construction complete or deleted

CEPP Chemical Emergency Preparedness Program

CERCLA Comprehensive Environmental Response, Compensation, and Liability

Act

CERCLIS Comprehensive Environmental Response, Compensation, and Liability

**Information System** 

CI confidence interval

CLU-IN Hazardous Waste Clean-up Information Website

CNS central nervous system defects

COI cost of illness

CVM contingent valuation method

CWA Clean Water Act

DNAPL dense non-aqueous phase liquid

DOD Department of Defense
DOE Department of Energy
DOI Department of the Interior

EECA Engineering Evaluation/Cost Analysis

EPA United States Environmental Protection Agency

EPA ReachIt Remediation and Characterization Technology Database EPCRA Emergency Planning and Community Right-to-Know Act

ERT Superfund Environmental Response Team ESD Explanation of Significant Differences

ETV Environmental Technology Verification Program

FY fiscal year

GIS geographic information system

GSI Ground Water/Surface Water Interface Criteria

Hazardous Substance Release/Health Effects Database

HC Health Consultation HPM hedonic property model HRS Hazard Ranking System

HSEES Hazardous Substances Emergency Events Surveillance Database

ICs institutional controls

IEUBK Integrated Exposure Uptake Biokinetic model

LA Linear Absolute model

LP Linear Percentage model
LULU locally undesirable land use
MEI maximally exposed individual
mg/kg milligrams per kilogram
MSA Metropolitan Statistical Area
µg/dL microgram per deciliter

MUS musculoskeletal system defects

NCEE National Center for Environmental Economics

NCP National Oil and Hazardous Substances Pollution Contingency Plan

NFRAP No Further Remedial Action Planned

NIEHS National Institutes of Environmental Health Sciences

NLA Non-Linear Absolute model NLP Non-Linear Percentage model

NOAA National Oceanic and Atmospheric Association

NPL National Priorities List NRC National Research Council NRD natural resource damages

NRDA natural resource damage assessment

NTD neural tube defect

O&M operations and maintenance

OIRA Office of Information and Regulatory Affairs

OMB Office of Management and Budget

OR odds ratio

ORD Office of Research and Development

OSC On-Scene Coordinator

OSWER Office of Solid Waste and Emergency Response

OTA Office of Technology Assessment

OU Operable Unit

PA preliminary assessment

Pb-B blood lead

PBT persistent bioaccumulative and toxic

PCBs polychlorinated biphenyls
PHA public health assessment
PPM property-based pricing method
PRP potentially responsible party

PV present value RA remedial action

RCC Resource Conservation Challenge

RCRA Resource Conservation and Recovery Act

RD remedial design

RI/FS remedial investigation/feasibility study

ROD Record of Decision
RSE Removal Site Evaluation

RSEI Risk-Screening Environmental Indicators Model RTDF Remediation Technologies Development Forum

RTU Return to Use Initiative

SAB Science Advisory Board

SACM Superfund Accelerated Cleanup Model

SARA Superfund Amendments and Reauthorization Act

SBA Superfund Benefits Analysis

SBRP Superfund Basic Research Program
SFIP Sector Facility Indexing Project

SI site inspection

SITE Superfund Innovative Technology Evaluation Program

SOD single-family, owner-occupied, detached home

SuperJTI Superfund Job Training Initiative SVOCs semi-volatile organic compounds TAG Technical Assistance Grant

TCE trichloroethylene

TOSC Technical Outreach Services to Communities

TRI Toxics Release Inventory

USDA United States Department of Agriculture

UST Underground Storage Tank
VCP Voluntary Cleanup Program
VOC volatile organic compound

WTA willingness to accept compensation

WTP willingness to pay

#### **EXECUTIVE SUMMARY**

Following increased public awareness in the 1970s of the national problem of abandoned hazardous wastes, Congress enacted the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) in 1980 and the Superfund Amendments and Reauthorization Act (SARA) in 1986. These bills were signed by Presidents Carter and Reagan and form the basis of the Superfund program. Together, these and related laws established a federal program for preventing, mitigating, and responding to releases of hazardous substances that might threaten human health and the environment. Six major approaches to the problem are taken under Superfund, as seen in Figure ES.1 and defined in Table ES.1.

Figure ES.1 and Table ES.1 also show nine benefit categories, divided into fundamental and embedded categories. The fundamental benefit categories are those found in the EPA's *Guidelines for Conducting Economic Analyses* (Exhibit 7-1, p. 67), and are the most basic reasons for the Superfund program: to mitigate human and ecological health risks, to improve other amenities, and to reverse environmental damage to materials. In many cases, these benefits are generated directly. However, there are other important outcomes, that are labeled embedded because they are direct objectives of the Superfund program and would likely be ignored if only the fundamental benefit categories were considered. Of course, the embedded benefit categories are valued largely because they lead *in*directly to the fundamental benefits (or to lower costs). Since it is not possible to quantify any future fundamental benefits, the distinction between fundamental and embedded benefit categories is a response to difficulties in measurement. In the current study, only fundamental benefits are quantified, so no issue of double counting arises.

**Approaches Benefits** Response Health Community Involvement Amenities Lead to Enforcement **Ecological** Research and Development Materials Fundamental **Training** Embedded Natural Resource Restoration **Empowerment** Deterrence **Emergency Preparedness** Information and Innovation International Benefits

Figure ES.1. Approaches Taken Under Superfund, and Resulting Benefit Categories

Table ES.1. Categories of Benefits of Superfund

Benefit	Definition
Fundamental	
Health	Actions taken to improve human health, which may include reducing the magnitude of exposure to contaminants, reducing the number of exposure pathways, reducing the length of exposure, and providing information so that individuals can reduce their exposure or seek medical treatment.
Amenities	Any feature of a place, object, or experience that enhances its attractiveness and increases the user's satisfaction, but is not essential to the place, object, or experience. In the context of Superfund, amenities include the removal of unsightly structures, the reuse of abandoned property, the avoidance of the stigma associated with contamination, and the reduction of perceived health risk from uncontrolled releases of hazardous substances.
Ecological	The restoration and maintenance of service flows to both humans and nature from natural resources, such as land, ground water, and habitat. These services may include recreation, clean water, shelter, food, timber, and others.
Materials	The reduction of risk and perceived risk associated with non-residential (i.e., commercial and industrial) properties, and the ensuing ability and willingness of the business and financial community to use these properties.
Embedded	
Empowerment	The ability of people who live near Superfund sites (especially NPL sites) to learn about the site(s) of interest, have questions about the site(s) answered, participate in decision-making associated with the site(s), and hold the relevant organizations accountable.
Deterrence	Incentives for firms and individuals that may create or use hazardous substances to handle and dispose of them properly and to avoid uncontrolled releases to the environment.
Emergency Preparedness	The knowledge, skills, organization, and technologies necessary to limit harm to human health and the environment following disasters involving the release of hazardous substances. Includes preparation for natural disasters, homeland security measures, and similar activities.
Information and Innovation	Increases in knowledge and technical capabilities created as a result of research, development, and deployment supported by the Superfund program. This includes both basic scientific research as well as efforts to develop and build experience and confidence in new technologies.
International Benefits	Any benefits from any of the other benefit categories that accrue to people or organizations outside of the United States. These benefits are generally coordinated with the State Department and often involve overseas response actions or training.

The Superfund program includes the following elements: enforcement authorities to negotiate or order response actions; a federal trust fund to pay for response to releases; and cost recovery authorities allowing the federal government to sue for costs of response actions under joint, strict, and several liability provisions. The Superfund program supports communities that are burdened with hazardous substance sites by providing them with a better understanding of, and opportunities to participate in decisions regarding the sites. The Superfund program supports a program for developing and deploying knowledge and technologies to better manage hazardous substances. This work provides a foundation for much of the current understanding and management of hazardous substances. The Superfund program provides training for thousands of first responders (fire fighters, police, emergency room nurses, etc.) so they can protect the public and themselves by detecting and identifying hazardous substances. This training provides essential elements of the homeland security capabilities of the United States. The Superfund

program has enabled the restoration of hundreds of streams, rivers, wetlands, and other places. Finally, the Superfund program has created powerful incentives for industry innovation to reduce the creation of hazardous waste, reduce the need for hazardous substances, and manage hazardous substances responsibly.

For the first time, the current study addresses the full range of Superfund benefits with the question: What are the benefits of Superfund for the period 1980-2004? To do so, this study enumerates the benefits of Superfund and describes each one, quantifies those benefits for which the appropriate data and methods are available, and monetizes benefits when possible.

For the purposes of this study, the Superfund program includes all the provisions of and programs created by, or attributable to, CERCLA and SARA. Due to data and methodological limitations, almost all of the quantification of benefits is associated with sites on the National Priorities List (NPL), although there is evidence that this biases the quantitative estimates of the benefits of Superfund downward by a non-trivial amount.

#### **Results and Discussion**

This study develops three partial and slightly overlapping estimates of the monetary value of the benefits of the Superfund program.<sup>1</sup> Each estimate uses a benefits transfer approach of some variety.

Many of the benefits of the Superfund program derive from response actions, which include, but are not limited to, remedial actions at sites on the NPL. For most people, it is the NPL alone that characterizes Superfund. However, removal actions are also important, as are state response actions. Figure ES.2 illustrates the total number of response actions attributable to Superfund for the period 1980-2004. This figure shows all federal response actions and 25% of state response actions as reported by 33 states, based on a rough estimate of the fraction of state budgets for response actions that is derived from federal sources. This approach ignores any role that Superfund has in encouraging private firms to participate in state-run voluntary cleanup programs or any other forms of federal support for state programs (e.g., training, research, and so forth).

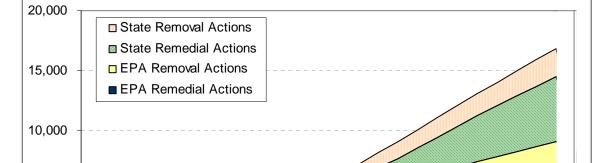
Importantly, these values do *not* address the risk addressed by any of these response actions; they only address the number of actions. There are no reliable data on the risk mitigation of removals or of state response actions, but there is some anecdotal evidence that at least some of these responses mitigate significant risks.

Based on these calculations, Superfund is responsible for slightly less than 17,000 response actions for the period 1980-2004, of which remedial actions at NPL sites make up less than 10%.

<sup>1</sup> The current version of this study is incomplete. By agreement with the EPA Science Advisory Board's Environmental Economics Advisory Committee, the analyses in Chapter 5 are not completed, only described. The agreed-upon process is for EPA to provide a description of the data and proposed methodology and submit a completed analysis based on input received from the Advisory Panel on the intended approach.

2005

Figure ES.2 illustrates these results. States report very large numbers of sites "in need of attention," suggesting that this level of effort could continue for some time.



1990

Figure ES.2. Total Superfund Responses

1985

5,000

1980

Chapter 4 presents an analysis that captures part or all of several benefits. It is a benefits transfer analysis of results from nine studies that have been published in the peer-reviewed literature that use market data about residential property sales.<sup>2</sup> This study performs a meta-analysis of the prior research, and applies the results in a benefits transfer analysis to all those NPL sites where remedial action occurred during the period 1980-2004. The meta-analysis indicates that homes within 2.5 miles of an NPL site experience a 7.4% decline in value at the time the site is discovered, or about \$10,000, and that for most sites this decline is reversed after definitive plans for remedial action have been made. The negative price effect is non-linear, so homes closer to the NPL site boundary suffer a greater effect. The benefits transfer analysis yields a partial estimate of benefits; it excludes benefits not likely to be reflected in home prices (e.g., ecological values) and benefits created by other actions attributable to Superfund (e.g., health risk reductions due to removal actions, or increased preparedness to respond to certain emergencies due to Superfund-sponsored research and training). Four different models are used for the benefits transfer analysis.

1995

2000

The mean estimates of the benefits measured by the four models range from \$63-\$100 billion over the period 1980-2004 (using a 3% discount rate). The 95% confidence intervals range from a low of \$41 billion to a high of \$130 billion. The best point estimate of the present value (1980, r=3% in year 2000\$) of the benefits of NPL remedial actions for the first 25 years of the Superfund program appears to be about \$63 billion. These results (for discount rates of both 3% and 7%) are shown in Figure ES.3. Converting these total estimates into annualized values yields an estimate of \$3.6-\$5.9 billion per year, assuming a 3% discount rate, with a best point estimate of \$3.6 billion per year.

<sup>&</sup>lt;sup>2</sup> The technical name for the approach these studies take is the hedonic price method.

Benefits of NPL Remedial Actions 1980-2004 Mean and 95% C.I. shown. Price effect for all homes is the same. \$140 \$120 r = 3%\$100 Billions (2000\$) \$80 r = 7%\$60 \$40 \$20 \$0 LP LA NLA NLP Model

Figure ES.4. Present Value of the Benefits of NPL Site Remedial Activities, 1980-2004 (Billion 2000\$, Base year 1980, 2.5 miles)

Note: Only a portion of the total benefits of Superfund is captured in these estimates. See text.

Chapter 5 contains descriptions of several effect-by-effect approaches that are proposed to estimate some of the health and ecological benefits of Superfund. These approaches are designed to avoid problems associated with risk-based data that have been proposed for use in similar benefits estimates in the past. The basic approach to the health effects is to estimate the number of cases of various negative health outcomes that will be avoided using either epidemiological or integrated exposure uptake biokinetic models, and a cost of illness approach to valuing these avoided health outcomes. For ecological benefits, the proposed approach is to use information from natural resource damage assessments to illuminate the type and magnitude of ecological benefits created by Superfund. Monetary values for a fraction of these benefits can be obtained, but adequate data do not appear to be available to quantify or monetize the ecological benefits of response actions at this time. Finally, several possible approaches to quantify the benefits of protection and cleanup of groundwater are proposed, along with one to monetize these benefits. However, none of these analyses is completed in the current draft of this study. Once this analysis is completed, these benefits cannot be added to the benefits estimated in Chapter 4 due to possible double counting.

Chapter 6 contains a detailed description of a number of benefits that cannot be quantified at this time.

The report concludes with a short summary and suggestions for future research that would aid in the regulation and management of hazardous substances.